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Does Time Spent Online have an Influence on Student Performance? Evidence for a Large Business Studies Class

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Abstract
This paper examines, using regression modelling, whether a statistically significant relationship exists between the time spent by a student using the course website and the student's assessment performance for a large third year university business forecasting course. We utilise the online tracking system in Blackboard, a web-based software system, to extract and calculate the time spent by each student on a range of specific online assessment activities across the entire semester. The evidence suggests that time spent online on the course website is associated with higher assessment performance.

Keywords
Online Learning, Student Learning Outcomes, Student Online Participation, Web- based software, Teaching Online

Introduction

The factors that influence student learning outcomes, particularly in light of recent technological advances, have become a topic of immense interest for educators and policy-makers. The rapid improvement in internet technology has witnessed a significant increase in the use of web-facilitated technology in education worldwide. This increased use has radically transformed pedagogical practices, as well as learning and teaching policies, across many universities (Eastmond & Ziegahn 1995; Romiszowski 1997; Calafiore & Damianov 2011). It is commonly argued that web-facilitated tools (e.g., online testing, discussion boards, emails, i-lectures and virtual chat) encourage students to actively participate in online learning activities that are expected to improve academic performance (Karayan & Crowe 1997; Smith & Hardaker 2000). The empirical evidence for such tools has generally focused on two main areas: (i) comparing online with traditional face-to-face course delivery modes (Farinella 2007; Palloff & Pratt 1999, 2001; Rafaeli & Ravid 1997; Vengroff & Bourbeau 2006) and (ii) an analysis of how variations in online-participation measures correlate with variations in student performance within a given course (Calafiore & Damianov 2011; Chan, Chow & Cheung 2004; Damianov et al. 2009; Michael & Miethe 1989; Zaiane & Luo 2001). The latter have typically examined how students' final grades in a course are affected by a single measure of online participation, such as time spent on the course website. However, few studies have holistically examined the potentially variable influences of different online participation components on student performance outcomes. Further, there are no studies, to our knowledge, that have examined whether online participation components differently influence various components of student performance (e.g., examinations, assignments, etc.).

From a policy perspective, significant differences in the effectiveness of different online participation components on disparate components of student performance has important implications for instructors, educators, universities and course website designers. If particular online participation components (e.g., discussion boards or forums) are found to have a significant relationship with student's performance outcomes, while others (e.g., i-lectures or virtual chat) do not, the instructor can divert course-delivery or web-development resources to gain the best outcome. Similarly, if there is a differential influence of online-participation components on the various components of students' performance (e.g., assignments or exams), the instructor can direct online resources to match the appropriate task at specific times during course delivery.

This research seeks to answer three questions. First, does online participation on a course website (*Blackboard*), in conjunction with face-to-face learning, improve student learning outcomes in a large business-forecasting course at an Australian university? Second, do various components of online participation have differential influence on overall student learning outcomes? Third, do the various components of online participation influence disparate student performance tasks differently?

There are several motivations for undertaking a study of this nature. First, from a pedagogical viewpoint, we seek evidence to test the hypothesis that the provision of online tools (in addition to traditional teaching) enhances student performance and learning. This evidence would also be of major interest for university administrators who wish to establish whether the significant investment in online technology contributes to improved learning outcomes and is cost-effective overall. Second, if online participation enhances learning overall, instructors are keen to know the pedagogical contribution of each online tool in improving learning outcomes; this knowledge can allow instructors to design course websites and use those online tools likely to further engage

students in the learning process and improve learning outcomes. Moreover, university administrators can allocate investment in online tools in a manner that either optimises learning for a given expenditure or minimises expenditure to achieve particular learning outcomes. Third, if online tools do, in fact, enhance student performance and learning, it would be instructive to know if they are as effective in improving student performance and learning for disparate performance tasks. For the instructor, the potential differential effect of online tools on various student performance tasks has implications for course website design and allocation of online resources over the semester.

Literature Review

There has been a great deal of research undertaken on the benefits and costs of online education and its impact on student learning. Generally, studies have focused on the characteristics of specific online tools, such as online messages, tests and discussion boards, and assessed their relative contribution to student learning (see, for example, Palloff & Pratt 1999, 2001; Davidson-Sivers, Muilenburg & Tanner 2001; Hara, Bonk & Angeli 2000; McKlin, Harmon, Evans & Jones 2001; Weisskirch & Milburn 2003; Davies & Graff 2005; Picciano 2002; Nachmias & Segev 2003; Zaiane 2001; Russell 1999). The empirical evidence typically supports the findings that specific online tools can improve and develop student learning. Other researchers have investigated the effectiveness of online learning by comparing learning outcomes in courses exclusively provided online versus those with a traditional teaching format. In contrast with the literature cited above, however, the evidence regarding the effectiveness of online learning tools in comparison with traditional teaching is mixed. Harmon and Lambrinos (2007) found that online teaching at least did not hinder learning outcomes relative to face-to-face teaching when used in an MBA program. Russell (1999) found that there was no significant difference in learning outcomes between traditional classrooms and online courses. Farinella (2007) examined the relative performance of students and professors in online versus face-to-face teaching and found that the cohort of students enrolled in online courses underperformed the traditional cohort by an average of 21 points on the final examination.

Although the evidence regarding the comparative effectiveness of online learning tools is mixed, this may be explained, in part, by the different cohorts enrolled in the two types of courses (for example, part-time versus full-time, age groups or family responsibilities), the actual courses (faculty area, undergraduate versus post-graduate, etc.) or other contingent factors. Therefore, unless all important factors are considered and incorporated into the analysis, results and conclusions from such studies are problematic and must be treated with caution. However, it would appear less problematic to consider the effectiveness of online tools by analysing the impact of online usage on student performance *within* a particular course that uses a hybrid of traditional and online approaches. In such circumstances, the impact of many of the factors raised above would likely be small, or even negligible. Although fully online courses have been established for a number of years, within Australian universities the hybrid-type course, using both face-to-face teaching and online tools, is far more common. In general, online tools are used to augment and enhance teaching and learning in traditional courses, rather than being employed as pure substitutes. Therefore, for the purposes of this study, the evidence within the literature regarding the effectiveness of online learning tools when used in conjunction with traditional teaching methods would be more relevant and instructive.

Most of the studies that examine the effectiveness of online tools as enhancements to traditional teaching focus on some measure of online participation or engagement, and relate this to measures

of student performance. These studies vary not only in the participation measure used in the study (such as time spent online, discussion messages read or written, online files downloaded or online sessions) but also on the method of data collection. A range of studies have relied on surveys in which students self-report the amount of time spent online on study (see, for example, Michael & Miethe 1989 and Williams & Clark 2004, among others). The major drawback of these types of studies is the validity of the self-reported measures and the lack of completeness of the data.

Other researchers have tried to overcome the deficiency of self-reporting data by using computer logs of course-related online activities (see, for example, Peled & Rashty 1999; Rafaeli & Ravid 1997; Zaiane & Luo 2001). Rafaeli and Ravid (1997) examined the correlations between student achievement and course-related computer-usage behaviour measures and found that students' online participation was able to predict 20% of the variance in the students' grades. Vengroff and Bourbeau (2006) sampled 80 students in two introductory psychology courses and found that students who consistently used *Blackboard* performed better on examinations than students who used it less frequently, even after controlling for their grade point average (GPA).

Recently, several key studies have explored actual time spent online as a performance metric for student participation. Damianov et al. (2009), using a multinomial logistic model and a range of control variables (GPA, gender, age, major, etc.), found a positive and significant relationship between time spent online and grade for a large business course in South Texas, particularly for students who obtained grades below B. However, they found no significant difference for students obtaining grades from B to A. In a recent study, Calafiore and Damianov (2011) found, using 2008 data for courses with online components offered by the Economics and Finance Department of a large public university in south Texas and an ordered-choice model, that both GPA and actual time spent online were associated with higher grades.

Most of the above studies have used a single measure of online participation and related this to student performance in final examinations or final grades, which typically included within-semester assessment. However, it is unlikely that a single measure will adequately capture online participation, which typically consists of many disparate online activities such as reading files, reading and writing discussion messages, participating in virtual chats and downloading and listening to iLectures. It is also unlikely that each of these components will have identical effects on student performance. The conclusions from these studies must thus extend only to the online tool used in the study, not online participation overall.

Chan, Chow and Cheung (2004) endeavoured to overcome this issue. They constructed a "student participation index" that included log data on the number of web pages viewed, forum questions read and posted and chat sessions participated in and submitted, and found that students with a higher index usually achieved better grades. While this index can be viewed as a better measure for online participation, the weights used in the construction of the index by the authors were arbitrarily set. Any significant differences in weights used in constructing the index would likely lead to different analytical results and conclusions.

Overall, the literature seems to suggest that online tools and online participation enhance student learning outcomes. However, most of the studies, apart from Chan, Chow and Cheung (2004) and Rafaeli and Ravid (1997), examine the influence of a *single* online-participation measure on a *single* student-performance measure. It is possible that different online tools (and hence measures of online participation) will have different effects on student performance. It is also likely that the influence of online tools will vary across various measures of student performance. There is no study to our knowledge that simultaneously examines online participation over a range of

measures *and* on more than one student-performance measure. This study, in contrast to previous studies, will examine the simultaneous relationship of various online activities, such as discussion messages read, online sessions, actual time spent online and online assessments undertaken, with two measures of student performance: formal and non-formal examination. In contrast with Chan, Chow and Cheung (2004), the weights attributed to the various online tools on student performance are not determined arbitrarily, but through regression analysis. The next section discusses in more detail the data and methodology used to analyse how various online tools affect the two measures of student performance examined in this study.

Data and Methodology

We obtained data for this study from a third-year level course in business forecasting at a major Australian university. In addition to normal lectures and tutorials that were conducted on a weekly basis, a suite of specific materials were made available online via *Blackboard*. This material included lecture slides, tutorial documents and other supplementary materials, such as self-testing question banks (with answers), additional forecasting data examples, forecasting notes and a discussion board facility, where students would discuss in great detail issues of data management, forecasting techniques and other academic content.

Two dependent variables were considered in this study. Overall student performance (final numerical grade) was decomposed into two separate performance measures: their performance in the final examination component of the course (weighted at 50% of the overall final numerical grade and conducted at the end of the semester) and in the non-final examination components (also weighted at 50% of the overall final numerical grade, but conducted within-semester). This decomposition of overall student grades was chosen because student learning and performance outcomes may be reflected or measured differently by diverse assessment tasks undertaken under a range of conditions.

The non-formal examination component was composed of a number of individual assessment tasks (i.e., assignments and class tests) that were conducted within the normal course of the semester. There were four individual assessment tasks: assignments 1 and 2 were 10% and 20% respectively; class tests 1 and 2 were weighted at 10% each. The assignments were generally short-answer questions and forecasting-calculation tasks that were submitted in the form of a management-style report. The class tests consisted of 30 multiple-choice and true/false (with explanation) questions. Students were not permitted to use notes or aids other than calculators in the class tests. The assessment tasks were completed in weeks 5, 8, 12 and 13 of a 13-week semester. The marks obtained for each within-semester assessment were weighted (as indicated above) and combined to form a total mark out of 100.

The performance in the final examination was the mark (expressed as a percentage) attained by the students in the formal examination for the course, held in the official examination period after the end of the 13-week semester. It consisted of questions requiring short written answers and calculations. Students were not permitted to use notes or other aids in the formal examination, other than calculators.

The independent variables were derived from two sources: (i) *Blackboard* and (ii) the university's student-data system. The student activity in the various online components was measured by the student-tracking facility of *Blackboard*. Although this did not provide a complete log of student activity online, it was possible to decompose total student activity online into relevant

components, such as total number of unique sessions, completed online self-tests, number of discussion messages read and sent, actual total time spent on course content pages and time spent downloading lecture slides and tutorial files. The log of online activity was collected and collated immediately after the completion of the final assessment task in week 13. Student characteristics such as GPA, gender, country of origin (domestic/international) and any other relevant information that could be related to performance were obtained from the student-data system.

The initial sample size, after accounting for a small number of observations with missing values, was 314 students. However, this was reduced to 270 for reasons explained below. The student cohort had the following characteristics: 48% were female and 52% male; 8% were Australian domestic students and 22% international students; and the students had an average GPA of 2.43 (max limit GPA = 4). The characteristics of the entire group were broadly consistent with typical third-year courses in business and economics at this university.

The dependent and independent variables are described as follows:

(a) Dependent Variables:

- **(i)** ***Mark_Exam*** **(Y1)** – Performance in the formal examination (%).
- **(ii)** ***Mark_Other*** **(Y2)** – Performance in assessment tasks other than the formal exam (%).

(b) Independent Variables:

- **(i)** ***Sessions***: Number of log-on sessions.
- **(ii)** ***Total_Time***: Total time in minutes spent on activities related to course content (not discussion board or online self-testing questions).
- **(iii)** ***Disc_Mess***: Number of discussion board messages read.
- **(iv)** ***Selftest***: Number of completed online self-test question sessions. Each online self-test session consisted of 20 randomised questions from a large question bank. Students were expected to attempt one question at a time and could only submit the test for grading and feedback at the completion of the full set of questions. Students were able to undertake the self-test assessment as many times as they wished to improve their learning outcomes.
- **(v)** ***Files***: Number of files students accessed related to course content and supplementary materials.
- **(vi)** ***GPA***: Student grade point average; maximum attainable = 4, minimum = 0.

The quantitative nature of the dependent and independent variables allowed us to conduct OLS regressions using SPSS version 19.0. We also used E-Views to cross-check our results. Since the measures in this sample represent overall performance for the semester and the cumulative online participation over the first 13 weeks, no time-series effects or analysis were considered.

Discussion of Results

We undertook exploratory descriptive analysis of the data prior to the regression analysis. The distribution plots of all variables were examined for evidence of atypical values. Using statistical methods (median, inter-quartile range multiples, etc.), several outliers for each variable were identified and the entire observation was removed from the data. This reduced the workable sample from 314 to 288 students. In addition, examination of the *Disc_Mess* data showed a

substantial spike at the zero value (18 observations). These observations were removed from the dataset due to estimation-bias concerns (censoring), leaving a final data set of 270 observations. The distribution plots of the variables were all acceptable, with the dependent variable exhibiting approximately normal behaviour. Some of the independent variables exhibited slightly right-skewed distributions; however, these were judged not to unduly influence the estimated results. Table 1 gives summary descriptive measures for the variables.

TABLE 1: Descriptive Summary Statistics

Vars	*Mark_Ex*	*Mark_Other*	*Sessions*	*Total_Time*	*Disc_Mess*	*Selftest*	*Files*	*GPA*
Mean	62.87	68.32	61.86	1577.46	545.82	3.10	105.89	2.42
Med.	64.00	69.15	57.50	1350.00	501.00	3.00	98.00	2.44
St. Dev	11.09	11.05	25.58	1053.70	411.39	2.26	38.54	0.64
Min	10.00	10.36	12.00	108.00	14.00	0.00	22.00	0.67
Max	83.00	91.28	134.00	3210.00	958.00	9.00	181.0	3.83

Correlation analysis on the variables was also undertaken to assess the strength of association of the independent variables with the two dependent variables (*Mark_Exam*, *Mark_Other*) and any potential estimation issues arising from collinearity between the independent variables. The variables *Sessions*, *Total_Time, Selftest* and *GPA* had reasonably strong correlations with the dependent variables, while the independent variables *Sessions, Total_Time* and *Files*, as expected, exhibited reasonable strength of association. None of the other independent variable correlations indicated any potential collinearity problems for estimation.

Although *Sessions, Total_Time* and *Files* would be expected to be similar indicators of students' online participation (outside of self-tests and discussion messages), variation may have occurred due to the different length of time each student took in viewing and absorbing online materials. Additionally students may have spent their time online on tasks other than opening and downloading files, which usually contained lecture slides and additional notes. Therefore, it was decided to include all these variables, as well as *Selftest* and *GPA*, in separate linear regression models for the two dependent variables. Variables such as *Gender* and *Country of Origin* (domestic/international student) were not considered since the scope of this study was primarily to examine the impact of online learning tools on individual performance outcomes. Tables 2a and 2b show the estimated results for the regression models using each of the dependent variables Mark_Exam and Mark_Other, respectively.

TABLE 2a: Initial Regression Results – Dependent Variable Y1 (*Mark_Exam%*)

Variables	Unstandardised Coefficients	Std. Error	Standardised Coeff - Beta	t-values	p - values
Constant	33.771	2.457		13.744	0
Sessions	0.053	0.025	0.123	2.110	0.036
Total_Time	0	0.001	0.027	0.501	0.617
Disc_Mess	0.001	0.001	0.020	0.388	0.698
Selftest	0.879	0.237	0.179	3.714	0

Files	-0.014	0.015	-0.05	-0.941	0.348
GPA	9.84	0.819	0.566	12.017	0

R	R-Square	Adj R-Square	Std. Error	F	Sig.
0.676	0.457	0.444	8.266	36.840	0.000

TABLE 2b: Initial Regression Results – Dependent Variable Y2 (*Mark_Other%*)

Variables	Unstandardised Coefficients	Std. Error	Standardised Coeff - Beta	t-values	p - values
Constant	41.83	2.537		16.489	0
Sessions	0.111	0.026	0.258	4.281	0
Total_Time	0.001	0.001	0.083	1.461	0.145
Disc_Mess	-0.004	0.001	-0.14	-2.604	0.01
Fin_Selftest	0.986	0.244	0.201	4.032	0
Files	-0.025	0.016	-0.089	-1.609	0.109
GPA	8.217	0.845	0.475	9.72	0

R	R-Square	Adj R-Square	Std. Error	F	Sig.
0.645	0.416	0.403	8.534	31.267	0.000

Overall, the models for both dependent variables are significant (F-statistic) with reasonable R^2 results for cross-sectional regressions. The diagnostic tests for heteroscedastic errors were negative, and further residual tests for non-randomness were all negative for both models. Visual inspection of residual plots suggested randomly distributed normal residuals for both models.

In both regressions the coefficients on the variables *GPA, Selftest* and *Sessions* were significant. In the regression for *Mark_Other* (the non-formal examination component) the coefficient on the variable *Disc_Mess* was also significant, while the coefficients on the other variables (*Files, Total_Time*) were not significant. Additionally, the last three variables were not relevant explanatory variables in the regression for *Mark_Exam*. Surprisingly, *Disc_Mess* had a negative sign in both regressions, indicating increased participation in online discussion board communication may *decrease* student performance and learning outcomes. However, there were a number of insignificant variables, indicating that model modification may be necessary before such conclusions can be made with confidence.

There is a likelihood that the insignificance of variable coefficients in these regression models may have been due to potential collinearity among key independent variables. In theory, the variables *Sessions, Total_Time* and *Files* are alternative measures of the amount of overall online participation by students. This is supported, to some extent, by significant estimated inter-correlations among these three variables.

To mitigate potential collinearity concerns it was decided to represent overall student online participation with only two variables – *Online_Time* and *AvgTime_Session* – instead of three. The *Online_Time* variable was used as previously defined; *AvgTime_Session* was determined by dividing *Online_Time* by the overall number of sessions (*Sessions*). This approach was selected for two reasons. First, a range of previous studies had used online time as the measure of online participation, and we considered it important for relative comparison of results between those studies and ours. Second, the inclusion of *AvgTime_Session* allowed for the impact of different patterns and consistency of time spent in online participation across online sessions to be examined. For example, the effect of 100 minutes of online participation on student performance over a single session could be differentiated from the same 100 minutes spread over 10 sessions. The former pattern may be indicative of a student cramming for assessment tasks in one session, while the latter may be indicative of more consistent engagement with course learning materials over the semester. Therefore, new OLS regression models were estimated for both dependent variables with the significant variables from the initial regressions and the new variable representing overall online participation (Tables 3a and 3b).

TABLE 3a: Final Regression Results – Dependent Variable Y1 (*Mark_Exam%*)

Variables	Unstandardised Coefficients	Std. Error	Standardised Coeff - Beta	t-values	p - values
Constant	35.068	2.222		15.78	0
Online_Time	0.002	0.001	0.150	1.757	0.08
AvgTime_Session	-0.086	0.057	-0.120	-1.498	0.135
Disc_Mess	0.001	0.001	0.036	0.710	0.478
Fin_Selftest	0.927	0.235	0.189	3.942	0
GPA	9.963	0.816	0.574	12.207	0

R	R Square	Adj R Square	Std. Error	F	Sig.
0.672	0.452	0.440	8.286	43.548	0.000

TABLE 3b: Final Regression Results – Dependent Variable Y2 (*Mark_Other%*)

Variables	Unstandardised Coefficients	Std. Error	Standardised Coeff - Beta	t-values	p - values
Constant	45.210	2.315		19.527	0
Online_Time	0.004	0.001	0.369	4.143	0
AvgTime_Session	-0.198	0.060	-0.278	-3.318	0.001
Disc_Mess	-0.003	0.001	-0.111	-2.090	0.038
Fin_Selftest	1.084	0.245	0.221	4.424	0
GPA	8.437	0.850	0.488	9.922	0

R	R Square	Adj R Square	Std. Error	F	Sig.
0.633	0.401	0.389	8.63293	35.282	0.000

Overall, the F-statistic suggests that the variables in both models were jointly significant. The adjusted R^2 values were slightly lower in comparison with the respective initial models, although some overall explanatory power was sacrificed to allow for the inclusion of the particular online participation variables (*Online_Time, AvgTime_Session*). The diagnostic tests for heteroscedastic errors were again negative, as were the residual tests for non-randomness. Visual inspection of residual plots suggested randomly distributed normal residuals. The coefficients on the variables *GPA* and *Selftest* were strongly significant in both regressions, and their respective coefficients had the expected signs. In the regression for the formal examination component in Table 3a, *Disc_Mess* had an insignificant coefficient; in contrast, it was significant in the regression for the non-formal examination performance (Table 3b). The sign on the coefficient of *Disc_Mess* in Table 3b was unexpectedly negative (and significant), implying that increased viewing of discussion-board messages was associated with *reduced* performance in the non-formal examination components of the course. The overall online-participation variable coefficients (*Online_Time, AvgTime_Session*) were both significant, while *Online_Time* was only significant at the 10% level and *AvgTime_Session* was not significant. The influence of increased online time on student performance was a combination of both the *Online_Time* and *AvgTime_Session* coefficients. The negative sign on *AvgTime_Session* suggested that spreading a given online time across a number of sessions *increases* the effectiveness of time spent online relative to fewer sessions.

The results have significant implications for developers of online resources that are also used in conjunction with face-to-face learning environments. As expected, *GPA* as a proxy for student ability is a major determining factor in student performance. In this study, a one-unit increase in *GPA* – for example, from 2 (Pass average) to 3 (Credit average) – leads to an estimated improvement in student performance (for the two assessments) of approximately 8.5 (*Mark_Other*) and 10 (*Mark_Exam*) points (the coefficients can be compared between regressions since the independent variables are measured identically and both dependent variables are measured as percentages). Moreover, each self-test assessment completion suggests an improvement to student assessment performance in both assessment types by, on average, one point (i.e. number of self-test assessments completed in this sample range from 0 to 9). Although the self-testing assessments can be provided off-line, online provision allows the educator to internally monitor whether students undertake the assessments and how many they attempt or complete, and the time spent on self-testing assessments. Furthermore, online provision provides instant marking and feedback for students, which can support learning outcomes. The results are consistent with previous literature findings that *GPA* is an important factor, and that self-testing assessments are important in enhancing learning outcomes.

The negative and significant coefficient on *Disc_Mess* in the non-formal examination component regression (Table 3b) suggests that the reading of discussion messages may have a *detrimental* effect on student performance, although this seems counter-intuitive, as it may reflect the quality of the discussion messages, which are almost entirely student-generated. An alternative explanation for this negative effect is that increased discussion-board activity may detract from other online activities (for example, lecture and tutorial content or self-testing). Furthermore, a more sensitive or fundamental measure of discussion-board activity may be required, as a portion of communication in discussion boards is typically only peripheral to course content (such as organising group activities or making routine enquiries). However, the negative effect of discussion messages read on student assessment performance is not evident for the formal examination component. This may be explained by the fact that assessment tasks, such as group assignments, have much longer gestation periods and opportunities for students to seek advice from other students, instructors and/or other student groups via the discussion board. The evidence

regarding the influence of discussion messages is thus rather mixed, and further research in a much wider context is needed to provide more-conclusive evidence of whether discussion-board activity aids, hampers or has no significant effect on learning outcomes.

The amount of time the student spends online (*Online_Time*) does seem to affect student performance. However, the effect depends on the type of assessment and the number of accompanying sessions. The evidence suggests that for the non-formal examination component there is a significant effect of time spent online, which appears to be moderated by the number of sessions over which the online time is spread. However, the effect of time spent online is only marginally significant for the formal examination component, with no evident moderating effect from the number of sessions. The evidence from both regressions seems to support previous studies' findings that the amount of time spent online on course websites does have some effect on student performance and learning outcomes. However, there is some overall evidence from this study that the marginal effect of the amount of time spent online is moderated by the number of sessions over which the time is spread.

Overall, there appear to be differential effects from the various online-participation components, depending on the type of measure of student performance employed. The influence of *GPA* as a proxy for student ability on performance seems more prominent in the formal examination component compared to the other components; however, the marginal impact of the online self-tests seems approximately the same for both components. The clearest difference between the two regressions seems to be in the effect attributed to discussion messages read and amount of time spent online. While these two variables are significant in the non-formal examination component, they are insignificant or marginal for the examination component. There appears to be evidence supporting the notion that the marginal effect of the various online tools varies between student-performance measures.

Conclusions and Implications

The main objective of this study was to examine whether a variety of online-participation web tools in conjunction with face-to-face learning significantly improve student learning outcomes in a business-forecasting course. We also endeavoured to establish whether the influence of various online-participation web tools varied depending on the type of measure used to assess student performance and learning. The overall results seem to suggest that the provision of online web tools, in addition to face-to-face learning, improves learning outcomes. Furthermore, online self-testing assessments that are immediately marked and incorporated with feedback appear to significantly increase student performance in assessment tasks. Moreover, increases in the overall time spent online (accessing course content, additional examples, additional notes, references, etc.) has a positive effect on student performance, although this effect is marginal for the formal-examination component.

The use of the discussion-board facility does not seem to positively affect students' assessment performance. In fact, the evidence suggests that it may have a *negative* effect on learning outcomes. While it is insignificant for the formal exam component, it is negative and significant for the non-formal examination component, which suggests that reading the discussion board may be *detrimental* to student performance.

The results of this study suggest that the influence of online components on student performance is more complex than previous analysis in the literature has concluded, and different online

components may be more suited to particular learning tasks in the overall learning process. This implies that previous empirical results are possibly influenced by the measure of student performance chosen for evaluation of student learning. For this particular business course, time spent online and, in particular the reading of discussion messages, may be better suited to group assignments and within semester assessments, rather than learning indicated by final exam performance. Further, if these differential effects are borne out by experience and additional research, educators, web designers and instructors should adopt different online-participation components that best suit different learning tasks.

Additionally, the marginal effect of time spent online varies depending on the number of sessions over which this online time is spread. Spreading the amount of online time over a number of sessions may indicate a more consistent and continual engagement with the course. This consistent engagement, rather than just the amount of online time alone, may be the reason for improvements in student performance and learning.

For university administrators and instructors, the evidence suggests that, overall, provision of online tools enhances student performance and learning. There appears to be a payoff for the investment of money (mainly by the university) and time (by the university and the instructor) in online technologies, although whether this exceeds the costs of provision cannot be answered by this analysis.

The differential effects of various online tools suggest that modifying course websites' design and/or use can enhance student performance. From the above analysis, instructors would be advised to continue with self-testing assessments and reduce reliance on discussion boards, which seem to negatively affect student performance. In particular, the discussion board’s negative effect is greater for the non-formal examination components of assessment. This may suggest that the instructor needs to monitor more closely the discussion board during the non-formal examination assessments, and possibly filter messages more meticulously during that period. From the university administrator's perspective, consistent evidence of the ineffectiveness of particular online tools may suggest shifting resources away from these tools to more effective ones.

The evidence regarding online time and average time per session suggests that it may be better for instructors to encourage more-consistent student participation with the course website. This can be achieved by instructors drip-feeding materials on a weekly basis (and possibly removing them after a certain time), rather than providing them all at once and/or keeping all materials available all the time. Alternatively, instructors may provide incentives for students to participate on a consistent basis, such as weekly virtual chat sessions, new web links or weekly marks for online participation.

It is important to note that this study, along with other studies of this nature, has a number of limitations that provide a basis for further research and investigation. Although the sample size was reasonable, a much larger sample across many and varied courses may be required before results can be definitively generalised. The course under investigation is a quasi-quantitative unit (business forecasting), and the results could be different if the course were more qualitative in nature. Furthermore, the course was at third-year level, with more mature and experienced students. These results may not be replicated with first-year courses with a younger and less experienced cohort of students.

Further limitations were provided by the measurement of the key variables. Assessment tasks are a proxy for student learning, and may not necessarily accurately reflect actual learning. Measures

such as logged sessions, total time spent and files accessed may not reflect students' interaction with the online materials. For example, one student may record a logged session to download a file, while another may record a session to examine some data examples and read additional notes. We are currently in the process of decomposing each student-logged session into more finely granulated constituent components (how long downloading files, how long accessing course content, etc.) to provide further evidence.

Similarly, discussion-board activity is proxied by discussion messages read. This may not totally reflect students' engagement with discussion-board communication and its efficacy as a learning tool. There is also an argument to suggest that it is the "quality" of the messages rather than the volume that influences student learning outcomes. The focus on "higher-quality" messages – those judged to contain potential learning content – may provide a better measure of discussion-board activity.

Student classification variables such as *Gender* and *Country of Origin* (domestic/international student) were not considered for this study. It is possible that the effects of the various online-participation components on student performance and learning may be moderated by gender and cultural variables that may reflect differences in learning styles. These variables will be examined in future studies to gain further insights into the demographic variables that may influence student learning outcomes.

This study is an important step in assessing the usefulness of online tools in improving student learning outcomes, given that universities around the world are investing an enormous amount of resources in online learning. Overall, the evidence suggests that online materials add additional value and enhance student learning outcomes, but the effectiveness of various online tools for student learning varies with the type of measure used to evaluate student performance.

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